



KENTUCKY TRANSPORTATION CENTER

**RECYCLING PRACTICES FOR
ENVIRONMENTAL MATERIALS**



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Research Report
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**RECYCLING PRACTICES
FOR ENVIRONMENTAL MATERIALS**

By

Sudhir Palle
Associate Engineer Senior, Research

Dr. Steve Higgins
Research Specialist
Biosystems and Agricultural Engineering

And

Theodore Hopwood II
Associate Engineer III, Research

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, Kentucky

In cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky

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EXECUTIVE SUMMARY

The Kentucky Transportation Cabinet (KYTC) initiated the study KYSPR 05-294 “Recycling Practices for Environmental Materials” to identify generally accepted practices for the handling of environmental materials by state highway agencies and compare those to corresponding KYTC practices. KYTC is also seeking to implement improved practices for handling/disposing of organic materials in an environmentally acceptable manner.

Two environmental materials identified as potential candidates for improved disposal practices: 1) tree & brush debris found on roadway right of ways resulting from ice storm damage and 2) large animal roadkill carcasses resulting from collisions with vehicles on state maintained roadways. Disposal methods for these materials were reviewed along with potential recycling applications. The study tasked KTC researchers to monitor and document all stages of pilot carcass composting projects undertaken at KYTC maintenance garages. Related practices of other state highway agencies (SHAs) were studied to determine whether they could be adopted by KYTC.

The study identified the four options for disposal of tree & brush debris and large animal carcasses; 1) incineration, 2) burial, 3) landfilling, and 4) composting. The resulting composted material could be used constructively to improve/alter soil and potentially assist KYTC in establishing desired vegetation. Incineration was considered best in situations involving disposal of a small number of carcasses (composting being more practical when many carcasses must be disposed of). Pilot programs were initiated at two facilities in District 5 to evaluate composting. These were monitored by KTC researchers.

In the course of this study, it was found that KYTC was practicing sound standard environmental stewardship and procedures at their regional maintenance garage facilities as evidenced from study advisory meetings. Some of the recommendations are: 1) identify locations within KYTC for starting composting piles based upon number of animal carcasses available for disposal, 2) include the two composting pilot projects in long-term monitoring to study final compost preparation (grinding) and end uses of the compost, 3) incineration should be studied further to determine whether it is a viable disposal method for KYTC, and 4) a chart should be prepared listing common composting materials that will promote decomposition of carcasses.

These steps would allow KYTC to evaluate promising disposal methods and recycling applications that could be employed based upon regional factors throughout Kentucky. This report also includes a list of safety equipment that would promote safe work practices for KYTC personnel directly involved in handling and disposing of animal carcasses that appeared originally in a preliminary draft report.

1. INTRODUCTION

Kentucky Transportation Cabinet (KYTC) is seeking to implement improved practices for handling/disposing of organic materials in an environmentally acceptable manner. Other state highway agencies (SHAs) are employing recycling to address disposal of tree and brush debris. Another practice used by other state highway agencies is the decomposition (composting and incineration) of large road kill carcasses such as deer in lieu of other options including open decay and burial.

1.1 BACKGROUND

This study was a continuation of KYSPR 05-294 “Recycling Practices for Environmental Materials” undertaken by KTC in 2005. Information obtained during that initial effort was provided to KYTC officials, but not officially reported. This continuing work was performed to identify current practices for the handling of environmental materials by other SHAs and to assist in developing and monitor pilot composting operations being implemented by KYTC in 2006.

Surrounding SHAs were previously surveyed by KYTC officials and by Maryland DOT personnel to determine how others are handling some of these materials (See Appendix A). Survey findings indicated that KYTC is at least on par with other SHAs in recycling of environmental materials. Two specific environmental materials were identified that could benefit from further investigation: 1) tree and brush debris and 2) large animal road-kill carcasses.

This study was intended to investigate the potential for treating these materials for recycling rather than for disposal as solid wastes. Best practices needed to be identified including facilities/equipment for composting/ recycling, manpower/cost requirements, compost analyses/testing, and potential uses for the recycled materials (e.g. soil amendment-in particular the establishment of turf, wildflowers, and other desirable vegetation). Options for in-house/contractor collection and recycling needed to be determined including the potential for centralized collection of those refuse for composting/recycling. Large animal composting needs were to be evaluated by establishment of a pilot operation in KYTC District 5. Details of composting, including facility design, compost medium, animal capacity, compost heap manipulation, pre/post-treatment (grinding) and compost spreading equipment were to be obtained prior to the start of that activity.

The study objectives approved by the Study Advisory Committee were:

1. Gather information on best practices for managing wood wastes. Determine if a centralized composting site is better than on-site chipping and spreading or landfill disposal.
2. Review the practices of other SHAs and KYTC Districts relative to large animal composting. Determine what practices KYTC can adopt for a compost operation.
3. Monitor a pilot large animal carcass composting facility in District 5 during its initial operation.

4. Identify beneficial uses for compost materials (e.g. soil amendment) to aid in establishing desirable vegetation.

To address those goals, KTC researchers were assigned five tasks.

Task 1. Review current sources of information on large animal composting at KYTC Districts. Conduct a site visit to a composting facility operated by the Indiana DOT or other neighboring SHA. Consult with UK Department of Agricultural Engineering on animal composting. Prepare recommendations for compost cell design, composting medium, animal carcass capacity, compost turning operations, necessary equipment, compost testing, worker safety requirements, estimation of compost cycle times, manpower requirements, and estimated costs.

Task 2. Monitor the construction and initial use of a pilot composting facility by KYTC District 5 officials (initially scheduled to begin in April/May 2006). Periodically monitor the decomposition of the compost, grinding operations, sampling and testing of digested compost by video tapping, and use of compost on KYTC rights of way.

Task 3. Review the practices of other SHAs and Districts at KYTC related to composting wood wastes. Identify best practices related to wood composting. Identify composting cell design, compost turning operations, necessary equipment, compost testing, estimation of compost cycle times, manpower requirements, and estimated costs.

Task 4. Determine beneficial uses of composts (e.g. soil amendment, slope stabilization). Determine feasibility of composting at centralized locations versus conventional disposal options. Focus on using compost to help establish turf, wildflowers and other desirable vegetation.

Task 5. Prepare a final report reviewing all research work performed. Provide recommendations for future composting operations with estimated costs and relative benefits of various composting options compared to conventional waste disposal methods. Provide a DVD that includes the pilot composting operation and constructive uses of the prepared compost for applications such as soil amendment and slope stabilization that can be used by KYTC Districts.

1.2 DEFINITION OF ENVIRONMENTAL MATERIALS

The environmental materials addressed in this study were trees & vegetation debris generated by ice and wind storms and road kill carcasses. If those materials remain on roadways, they present significant safety hazards to traveling public. In their removal from roadways, improper handling of these materials can also negatively impact the traveling public. Since the financial and labor resources used by KYTC for the collection, transportation, and disposal of these materials are significant, KYTC would benefit if alternate forms of disposal are identified.

In addition to the internal and external costs for the collection and disposal of trees and brush, the amount of brush materials to be handled requires a considerable amount of space to be allocated at the maintenance garages to store the collected debris. This storage space may be needed for six to nine months to expend the accumulated wood debris from a winter ice storms and other causes. Maintenance personnel chip and shred the wood debris and stockpile it for reuse or disposal.

The current methods for wood chip disposal are land filling or recycling by composting. Composted wood materials can be reused for plantings and erosion control projects by KYTC, by other state and local government agencies, or by deserving nonprofit and volunteer organizations. Stream reclamation and wetlands protection are two examples of beneficial uses of this material.

Roadkill carcasses pose a significant disposal problem to KYTC (Figure 1). It is not uncommon for a single KYTC area maintenance garage facility to collect, transport, and dispose of 20 to 30 large animal carcasses per week. KYTC area maintenance garages receive notification about carcasses from the Kentucky State Police working accident scenes, Transportation Operations Center, from a local police organization, from the public and/or haul them when they are found on roadway.

Animal carcasses can be classified in three sizes, small, medium and large. They vary in weight. Animal sizes and weights impact their disposal, handling and so require safety equipment to be worn by KYTC personnel which are listed in the recommendations section.

1. Small animals include opossums, skunks, squirrels, rabbits, foxes, coyotes and raccoons, and domestic dogs and cats. Small animals are less than 6.0 cubic feet in volume and can weigh as much as 20 pounds. Fortunately, small animal carcasses do not pose hazards to traffic.
2. Medium sized animals typically include the younger deer (one and two year-old animals-both bucks and does) that have not acquired fear of roadway traffic. They are typically 10.0 cubic feet or more in volume and can weigh as much as 120 pounds.
3. Large animals include older and mature deer, bucks and does, elk and domestic horses and cows. They range from 20 to 150 cubic feet in volume, and can weigh from 150 pounds to 1,500 pounds.

2. CURRENT KYTC PRACTICES

As part of tasks 1 & 3, composting operations currently undertaken at KYTC districts was reviewed by Mr. Ray Werkmeister's as part of his work on this study's predecessor. Estimated costs for composting both tree & brush debris and large animal carcasses were complex to calculate as it involved KYTC personnel and equipment. Disposal of wood debris resulting from construction projects is the responsibility of the contractor as defined by the provisions of a contract. For the most part, contractors abide by contract terms. If permitted by a resident engineer and local clean air regulations, contractor preference is to accumulate wood debris into centralized brush piles, burn them to ash, and spread the ash along the right of way. If burning is not permitted, the contractor preference is to shred the wood debris with a portable chipper and spread it evenly along the right of way as close as possible to the point of accumulation. The process of decomposition of the green wood chips in nature consumes vast amount of nitrogen, immobilizing it from the soil. This practice is undesirable. Nitrogen depleted soil requires significant nitrogen enrichment to be able to support vegetation during the growing season.

If disposal of wood chips along the right of way is not allowed, the contractor preference is to collect the wood chips and transport them to a recycling center for composting and reuse, or to a landfill for disposal. In special circumstances a contractor may be allowed to deposit the wood chips, or bulk wood debris, stumps and tree trunks at KYTC maintenance garage sites for storage and subsequent chipping and/or composting by KYTC personnel for reuse on maintenance projects involving erosion control and plantings.

Collection, transportation, and disposal of wood debris generated from ice storm damage are commonly performed by KYTC area maintenance garage crews. Urgency to clear the roadway of safety hazards dictates a rapid response and timely completion. That may require KYTC to outsource the work to contractors. Wood debris from this type of event would probably be accumulated and stored at maintenance garages. Of the methods available to the KYTC for disposal, burning of wood debris at maintenance garages is unacceptable, or at the least undesirable, because of environmental impacts. Most maintenance garage sites provide little or no privacy from public scrutiny and observation and open burning is often considered objectionable by the public. The preferred disposal method of the wood debris would be chipping, shredding, stockpiling, composting, and recycling for KYTC maintenance plantings, erosion control projects, and stream and wetlands reclamation projects.

Disposal of large animal carcasses from animal and vehicle collisions on state maintained roadways is KYTC maintenance responsibility (Figure 1). KYTC maintenance personnel, equipment, and facilities are used. Current KYTC large animal carcass disposal options include:

1. Allow the animal to remain and decompose at the place where it died, providing it would not create problems to the environment, watershed, etc. Allow the nutrients of the animal carcass to naturally return to the environment with the least amount of meddling from man. This may cause public notice due to visibility or the strong unpleasant odors associated with decomposition of the carcass in the open atmosphere. Also, various carrion feeders would be naturally attracted to the decomposing carcass, perhaps even causing further public notice and additional safety hazards to the traveling public.
2. Drag the animal carcass to a location out of the public sight, as close as possible to where the animal died. Locations in the woods, the brush, or behind a knoll should be sufficient to allow the carcass to decompose out of public view. Odors may remain in the vicinity of decomposition and still be detected by the public.

KYTC personnel would have to handle, lift, or drag the carcass that may not be a fresh kill with the decomposition process well underway. The carcass may also have substantial damage from the collision with the vehicle. There may not be suitable locations to place the carcass for decomposition.

3. Bury the carcass in a shallow pit as close as possible to where the animal. This disposal method would require the same handling issues raised above.

This would require Dig Safe® coordination for exact location to dig that would miss any buried utilities located on the roadway right of way. This coordination

would require time and personnel to handle the carcass with decomposition advancing.

4. Collect the carcass, transport and deposit it in a landfill. This disposal method raises handling issues previously noted. Fees and permits are required for disposal of animal carcasses at landfills. The cost of the fee is \$170 per truck load of up to 10 to 12 carcasses.

Animal carcasses could be collected and transported to a central location. Then they could be transferred to a larger truck holding up to 12 carcasses to be transported to the landfill for the more economical disposal than with using pickup trucks. This would require additional handling of the carcasses with advanced decomposition, transfer to and at central location and to the larger truck.

5. Collect the carcasses; transport to a commercial animal carcass incineration facility for incineration. This disposal method would include the handling issues noted above.

Fees and permits are also required for disposal of animal carcasses at commercial incineration facilities. The cost of the fees ranges from \$70 to \$90 per carcass. Commercial incineration facilities are usually only open for business during the week, and are closed on weekends. They are also typically located in populated urban areas.

6. Disposal of animal carcasses at rendering plants is no longer an available option, since rendering plants can no longer accept animal carcasses with an unknown history due to homeland security concerns.

3. RECOMMENDED PRACTICES FOR DISPOSAL

Disposing of a dead animal by dragging it into a wooded area or sink hole, dumping it in a stream, or leaving it to decompose are unacceptable. The acceptable options for KYTC are incineration, burial, disposal in an approved landfill, and composting per Kentucky statutes (KRS 257.160). Whichever acceptable method is preferred, it must be accomplished within 48 hours of the animal's death, unless the carcass is stored in a cooler.

3.1 INCINERATION

Kentucky laws allow the incineration of animal mortalities. Since this law was implemented in 1996, regulations regarding air quality have become more stringent. Therefore, the possibility of obtaining a permit to incinerate mortalities using a fixed facility would be very questionable, requiring air quality monitoring which would take time to obtain. Open burning is not recommended, because it creates more air pollution than fixed incineration facilities and not a viable option, for those close to or upwind of residential areas. However, if a pandemic occurs, creating large number of carcasses that had to be destroyed, then an emergency, short-term protocol would be established that

may involve incineration. This emergency situation would probably involve an air-curtain burner.

The greatest advantage of the incineration is the near complete combustion of the animal carcass in just four hours with only a very small quantity of ash to dispose of. Commercially available incinerator units are equipped with automatic controls and emissions-reducing features. They require little operator attention and are reasonably trouble free. Common non-road use diesel fuel is employed due to its availability and economy. It takes 10 gallons of diesel fuel to incinerate an average-sized deer carcass. Commercial incinerator units can hold two or three animal carcasses simultaneously. This size would be sufficiently large to handle the volume of animal carcasses anticipated at a KYTC maintenance garage. Top loading units facilitate filling the incinerator units using a front end loader or bobcat. A commercial incinerator costs \$8,278.25. A Burn-Easy double top loading door unit (6' x 30" Diameter) costs around \$4,000. A concrete pad with an open sided shed with 120 volt electric service to would be required to house the incinerator unit. This would cost several hundred dollars to construct. Refer figure 2.

KYTC Environmental Analysis Division believes these units would be exempt from air quality permit requirements, but that KYTC officials would need to formally document the process by completing the permitting paperwork.

3.2 BURIAL

Burial of animal carcasses is allowable, but expensive. According to Kentucky law (KRS 257.160), a carcass should be buried four feet deep with the body cavity vented (opened), covered with at least two inches of quick lime, and back-filled with at least three feet of soil. The burial site should be stable, and at least 100 feet from a stream, sinkhole, well, spring, public highway, residences. The burial site should not be in a flood plain or in an area with a high water table. As with any digging, the location of buried utility lines should be determined to prevent damage.

As noted above, Kentucky law requires that a buried animal should be covered with at least two inches of quicklime. The purpose of applying quicklime is to discourage scavenging by predators, prevent odors, inhibit earthworms from bringing material to the soil surface, and destroy harmful bacteria. Quicklime raises the pH making the local environment harsh for organisms to survive. When it is exposed to moisture, it goes through a chemical process that generates heat, which also destroys micro-organisms. Quicklime may destroy harmful bacteria and pathogens that cause mortalities. However, it also makes the carcass inhospitable for beneficial bacteria that breakdown the carcass and thereby inhibits decomposition.

Location is important consideration in burying an animal carcass. Although deep burial may place the carcass out of sight, many factors will affect its decomposition rate. These factors include soil temperature, rainfall, soil texture, soil pH, and moisture. A carcass may still be present many years after burial. In addition, the location of water resources and consideration of soil properties (depth to bedrock, permeability, slope, etc.)

are important in order to prevent contamination of water resources. Research has shown that mature cattle will release approximately 160 liters of liquid in the first two months of decomposition. This liquid, or leachate, can move into water resources, so a burial site must be selected away from streams, sinkholes, and wells

3.3 LANDFILLING

Approved landfills can be used for dead animal disposal, but they may not be convenient. KYTC personnel may be required to drive long distances to the nearest landfill, and have to pay a tipping fee for using it. If a landfill agrees to accept a carcass, it should be covered during transport and the vehicle disinfected afterwards.

3.4 COMPOSTING

Composting gives KYTC a convenient method for disposing of animal mortalities, while providing a valuable soil amendment when land applications are made of the composted material. Composting is a natural decomposition process conducted by microorganisms that can be controlled under managed conditions. Composting reduces the bulk of material by liberating organic products, water, and energy in the form of carbon dioxide, vapor, and heat. In addition, pathogens, which cause approximately 80% of animal mortalities, are destroyed during the composting process. Composting has several disadvantages: it requires time and space; nitrogen (N) is lost; and some specialized equipment may be needed. If composting is not performed correctly, pathogens can survive and odors may occur.

Kentucky law (KRS 257.160(1)(f)) allows disposal of animal carcasses by composting if it is performed in an approved facility according to the Agricultural Board's administrative regulations (302 KAR). A permit is required to legally compost mortalities, which is issued by the State Veterinarian. The cost of the permit is twenty-five (\$25) dollars and shall be renewed every five (5) years. The permit application requires the name and address of the compost owner, the location of the composting facilities, and a description of the facilities and composting procedure. All animal composting facilities are subject to inspection by the State Veterinarian or his/her representative. Any animal carcasses not composted should be disposed of in a manner consistent with KRS 257.160 and 401 KAR 30:031.

Kentucky Administrative Regulation 302 KAR 20:052 states that a permitted composting facility should be constructed to meet or exceed the current United States Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard for Composting Facility, Code 317, (July, 1998) in Section IV of the Kentucky Field Office Technical Guide and the requirements of the Kentucky Agriculture Water Quality Plan. All processing of dead animals shall be done within the permitted facility. Dead animals to be composted shall be temporarily stored indoors on floors constructed of concrete. This requirement is intended to control the leachate while not allowing other animals (i.e. rodents and birds) to become contaminated.

Kentucky law requires that reasonable and cost-effective efforts be taken to prevent odor, insects, and pests. All carcasses must be inaccessible to scavengers, livestock, and live poultry. Typically, this means that the structure should have walls, doors, and a roof, which is a good practice to prevent vector transport of contagious diseases. Composting is a controlled process that cannot be managed properly if scavengers are allowed to drag carcasses away from the composting site. Preventing and limiting odors, insects, pests, scavengers, and other animals are facilitated by using a secure facility. Methods to improve the composting process include reducing and cleaning up spillage outside and around the facility to limit flies and other animals from intruding on the process. Use finished or stable compost such as a bulking agent will inoculate the pile with beneficial bacteria to jump start the composting process. If the bulking agent and carcasses are dry, it may be desirable to add a little water, but not over apply it. Excessive water can change the composting process from aerobic to anaerobic resulting in an unpleasant odor. It should be noted that animal decomposition actually occurs as an anaerobic process in the area immediately surrounding the carcass. Therefore, addition of a stable layer of finished compost as a blanket above the carcass layer provides a method for abatement of anaerobic gases as they rise up through the pile. Anaerobic gases are removed by the beneficial bacteria that exist in the finished compost. Since gases are abated or removed, pests and scavengers that would normally be alerted to the location of the decaying carcass by smell are not attracted to the compost pile.

To facilitate composting, animals weighing over 300 pounds should be cut into pieces small enough to ensure complete composting (i.e., quartered). The rumens of all ruminant animals should be vented prior to composting to prevent the carcass from exploding from trapped gases and thereby exposing the carcass. If this should occur, more bulking agent must be added as cover. Although composting of animal mortalities is somewhat of a passive process, the pile should be periodically checked for temperature, moisture, odors, etc. As apart of the decomposition process, shrinking of carcasses will occur and requires additional topdressing with a bulking agent.

3.4.1 TYPES OF COMPOSTING STRUCTURES

Composting animal mortalities can be accomplished using traditional composting facilities like stack pads, bins, windrows, and vessels. A stack pad is the simplest method of composting. Ideal stack pad facilities have a roof and a flooring material that is impervious, such as concrete, to operate without creating a discharge. Unroofed facilities have the potential to discharge nutrients and pathogens from the site and will be scrutinized by the Kentucky Division of Water. Therefore, compost facilities that don't have a roof should have a mounded compost pile to bleed off water and have the ability to collect runoff water. The Kentucky Department for Environmental Protection requires that the compost facility be capable of collecting and detaining the runoff from a 24-hour, 25-year storm. If KYTC uses unroofed composting sites, they may want to consider plumbing runoff to an animal waste storage structure (Earthen storage structure, lagoon, etc.). A disadvantage of an uncovered composting structure is that precipitation controls the composting process. Typically, Kentucky weather conditions in the winter and spring months provide too much moisture. High moisture causes air voids to be replaced with

water. Combined with less optimum composting conditions, like decreasing temperature, the composting process begins to shut down, leading to anaerobic conditions and putrid odors. For these reasons, it is best to use roofed facilities when composting mortalities.

The bin system employs a structure containing partitions to separate piles of compost. Typically, each bin represents a different composting stage. Periodically, the bins are turned using a front-end loader or moved to a new bin for further breakdown or curing. Probably the most expensive method of composting is the vessel system, which uses fans to force or pull air through the compost, and motors to rotate the structure. Vessel systems have been shown to work well for poultry mortalities, where the birds were frozen then run through a chipper and placed directly into the vessel.

The type of composting method used will depend on the type and size of the animal operation. Composting structure with a roof is ideal as it controls precipitation, sides to keep out scavengers and facilitate loading and turning, and a concrete pad to control leachate loss.

3.4.2 CONTROLLING THE COMPOSTING PROCESS

Optimum conditions are needed to keep the compost pile decomposing properly. The ideal C:N ratio for an initial pile is 30:1, with a range of 20:1 to 40:1 being acceptable. Other optimum conditions for composting include an internal temperature of 140 to 160° F, a moisture content of 40-60%, 30% porosity, and a pH range of 6.0 to 8.0. These conditions are usually met in laboratories and for outdoor composting operations, it is recommended to keep it close to the above conditions for decomposition to occur.

A bulking agent is vital for controlling the decomposition process. A bulking agent soaks up the liquid produced by the decomposing carcass, provides good aeration, and increases the carbon to nitrogen ratio. Examples of traditional bulking agents are sawdust, wood shavings, horse muck, poultry liter, and corn stalks. Typically, 1.5 to 2 feet of bulking material is placed below the corpse. At least 1 foot of bulking material should cover and surround the sides of the animal. Completely covering animal parts will help control odors and deter scavengers from exhuming the carcass.

3.4.3 CHOOSING A COMPOSTING SITE

The State Veterinarian is responsible for permitting animal composting facilities (302 KAR 20:052). Ideally, a mortality composting facility should have a concrete floor and bin walls constructed of concrete or treated lumber. The width of the bin should allow easy access by loading equipment. The composting area should not be built in a flood plain or within 300 feet of a water well, stream, pond, property line, or public road. Preferably, the compost area should be covered with a roof to control precipitation. A hydrant should be located nearby to facilitate watering the pile. Ideally, any leachate lost from the compost pile should be diverted to an existing manure storage structure or grass filter strip.

3.4.4 MATERIALS NEEDED

Besides an approved composting facility, a cutting instrument may be needed to lance and expose rumen contents, because animals weighing over 300 pounds should be cut into smaller pieces (quartered) to facilitate decomposition. A front-end loader used to place carcasses in the pile, move the compost material from bin to bin, and turn or flip the pile contents is an excellent tool for dismembering carcasses. A temperature probe is useful to determine the activity of the microbes and monitor the composting process. A moisture probe is also useful to monitor the moisture content of the compost.

3.4.5 COMPOSTING PROCESS

Animal mortalities and bulking material can be added until the pile reaches an adequate size. The smallest size would be a 3-foot cube (1-cubic yard). A pile of that size would be able to tolerate fluctuations in ambient air temperature. Additional mortalities may be added until the pile reaches the upper limits of a manageable height, which would depend on the type of equipment and structure available. A one-foot free-board should be maintained when using a bin system. Refer figures 3 thru 5.

The time that it takes to complete the composting process will depend on the composting conditions, size of the animals, and composting technique. A pile of carcasses should be completely composted within two to six months, but should not be turned for the first 30 to 45 days. Larger carcasses such as deer should not be turned for 55 to 60 days. There is little agreement on the characteristics of a “stable” pile. Typically, a pile is stable when the material has the color and texture of peat moss, and when the temperature is unable to rise greater than 15° F above ambient. Commonly, if optimal conditions are met; a compost pile will never become truly stable, and will continue to decompose; the pile will continue to give off heat as long as water, nutrients, and air are available. Stable material can be reused to compost additional mortalities and it can be land applied as a soil amendment on state property. The material should not be used in public areas unless the remaining bones are broken up using a tub grinder.

4. PILOT PROGRAM OBSERVATIONS

Prior to starting pilot programs in Kentucky, members of study advisory committee for KYSPR 294 visited an Indiana DOT (INDOT) facility in the Greenfield District on April 18, 2006 to look at their composting facility. INDOT officials demonstrated the facility including composting tools, space, types of facility requirements and composting operations. The attendees also inspected a nearby INDOT incineration facility.

KYTC subsequently established two pilot programs at its maintenance garages in District 5: one at Shelbyville and the other at Middletown. Personnel from KTC and Biosystems and Agricultural Engineering at UK were involved in monitoring and providing guidance in establishing the two pilot projects as part of this study as part of task 2.

The composting operation began on June 22, 2006 in a temporary location at the Middletown maintenance garage. It is an outdoor location with an adjacent detention pond to receive any runoff. In this operation, large wood chips were used to start the compost pile as they were readily available. It resulted in inadequate cover of the carcasses and resulted in a foul odor that attracted buzzards. The large wood chips also delayed the decomposition process due to insufficient retention of moisture necessary to start the composting process. Subsequently, finer wood shavings were added to the pile after it was moved to a different location in the garage area on December 13, 2006. In KTC field inspections after the move, temperatures inside the pile were found to be in the optimum range and decomposing was on track. Some resulting compost was spread on March 19, 2007 to grow vegetation in the garage area.

The second composting operation was started at Shelbyville maintenance garage on December 12, 2006. This was also an outdoor location. It was started with a mixture of wood chips, wood shavings and some muck that was brought in from surrounding farms. When this pile was turned on March 27, 2007 (about 3 months after starting), most of the decomposition had already occurred with some big bones showing thru. During subsequent monitoring of the site by KTC personnel, temperatures of the compost pile were within the optimum range and decomposing was taking place as intended.

5. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, composting offers an acceptable method for handling waste materials including wood debris and animal carcasses that will enable the resulting composted material to be used constructively to improve/alter soil and potentially assist KYTC in establishing desired vegetation. This helps KYTC minimize waste disposal and recycle materials rather than dispose of them by land filling. Incineration can be setup as an alternate and be used in cases where the number of carcasses is few (Less than 10 per week). Covered composting is preferred, but if there is no cover available, then care must be taken to maintain adequate moisture for decomposition to take place. The current method of disposal of carcasses in rural areas by natural decomposition is a potential option but the legalities of it need to be clarified in discussion with Division of Solid Waste at KYTC.

The KYTC pilot projects are a starting point for composting large animal carcasses in the state of Kentucky. As with any new initiative a learning curve was associated with it and as of date, the two composting pilot operations have shown potential for future deployment at other KYTC districts. Task 4 could not be accomplished before the end of study as the pilot projects did not produce enough compost to test at different sites. The DVD that includes the pilot composting operation and constructive uses of the prepared compost for applications such as soil amendment and slope stabilization that can be used by KYTC Districts could not be made due to malfunction of the recorder and this can be accomplished when the next operation is identified.

Some of the recommendations are as follows.

1. Identify locations within KYTC for starting a composting pile based on number of animal carcasses available for disposal.

2. Include the two pilot projects for long-term monitoring to study final compost preparation (grinding) and end uses of the compost.
3. Tasks that were incomplete under this study should be included in long-term monitoring.
4. Incineration should be studied further to determine whether it is a viable disposal method for KYTC to adopt.
5. A chart listing common composting materials that will help in decomposing (Appendix B) was developed by Mr. Ray Werkmeister.

Below is a list of KYTC Protective Personnel Equipment that is recommended and that appeared in a draft report written by Mr. Ray Werkmeister.

1. Blaze orange vest for ease of identification by motorists
2. Flashing safety lights on vehicle
3. Full face shield, attachment to hard hat, to protect worker from contact with animal carcass fluids
4. Painter's mask or respirator to prevent ingestion of fluids, and assist with inhalation of gases and control of odors.
5. $\frac{3}{4}$ length rubber gloves, covering up to and including forearms
6. Full rubber apron, covering the front and sides of worker when working with carcasses
7. Study work boots with disposal boot covers when working with carcasses to prevent contact with fluids
8. Trucks equipped with a Tommy Lift at rear tailgate, or Small Crane with 500 lb or more rating, block and tackle, truck mounded electric wench (fore and aft)
9. Trucks should be equipped with Full bed liner for easy wash up and rinse out of any deposited fluids from transport
10. Lifting belt to support workers back during dragging and lifting

6. REFERENCES

1. On-Farm Composting Handbook. (NRAES-54). 1992. Robert Rynk Ed. Northeast Regional Agricultural Engineering Service. Ithaca, NY.
2. United States Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard for Composting Facility, Code 317, in Section IV of the Kentucky Field Office Technical Guide (July, 1998).
3. Kentucky Agriculture Water Quality Plan (October 1996, revised May 1999).

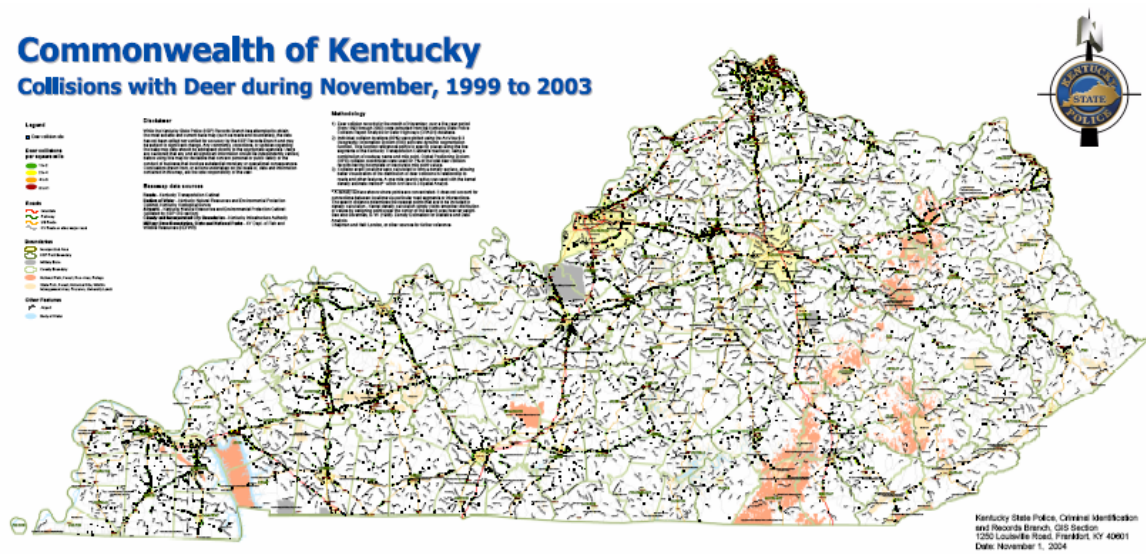


Figure 1 Deer and Vehicle Collisions in the Commonwealth of Kentucky, 1999 to 2003



Figure 2 Incineration Facility

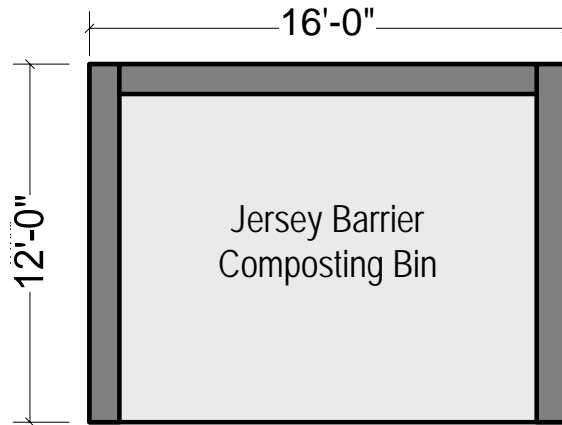


Figure 3 Proposed Compost Bin Configurations (Plan View)

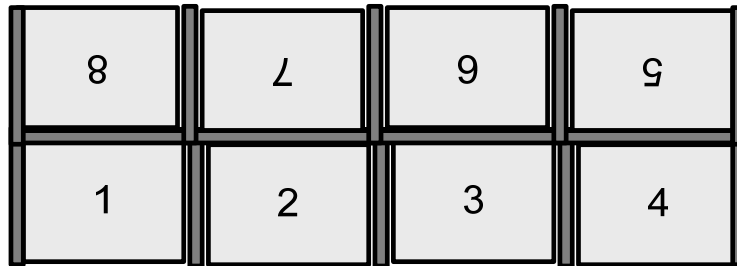


Figure 4 Proposed Compost Bin Arrangement Layout (Plan View)

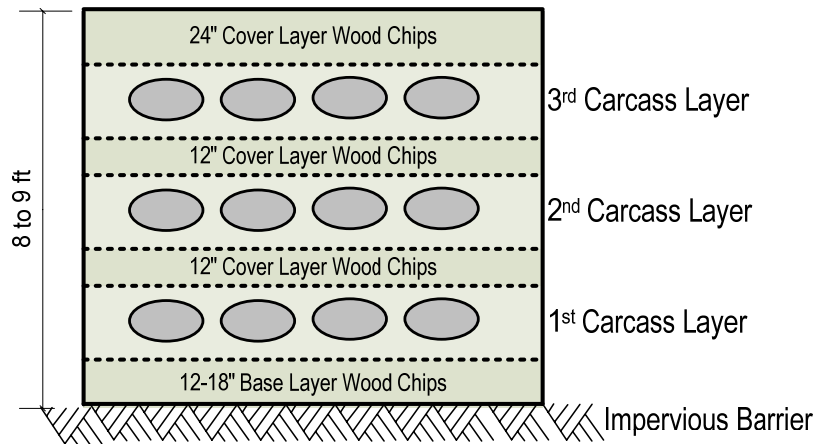


Figure 5 Proposed Animal Carcass Stacking Pile Compost (Vertical Section View)



Figure 5 Compost pile at Middletown facility is being turned



Figure 6 Temperature measurement being taken at Middletown facility



Figure 7 Compost used for growing vegetation at Middletown facility



Figure 8 Chosen site for composting at Shelbyville facility



Figure 9 Muck being added to wood chips and shavings at the compost pile at Shelbyville facility



Figure 10 Pile being turned over at Shelbyville facility



Figure 11 Temperature reading of the compost pile at Shelbyville facility

7. APPENDIX

7.1 APPENDIX A: SUMMARY OF RESPONSES TO MARYLAND SURVEY ON ANIMAL CARCASS DISPOSAL

State	Contact	Pick Up	Disposal	Comments
Alberta, Canada	Steve Otto, Operation Standards Engineer, Alberta Infrastructure & Transportation, 780-422-9972 steve.otto@gov.ab.ca	By contract	In Alberta, our standard practice is to remove and dispose of larger roadkill in a convenient landfill; we haven't had to consider use of composting facilities. In some areas of the province, it is still isolated enough that roadkill can be removed to the edge of the right of way and left for 'natural recycling'	The link to our highway maintenance specifications for carcass disposal is in Section 54.39.4.3 in: http://www.trans.gov.ab.ca/Content/doctype2/production/53_039.pdf
Arkansas	Pat Sullivan Staff Maintenance Engineer Ph. 501-569-2569 Pat.Sullivan@arkansashighways.com	Arkansas highway workers	Arkansas highway workers usually bury road-kill on the highway right of way. If this is not possible the animal is transported to a local landfill. In the past, way back, there had been a directive to bury livestock where found and not to transport.	
British Columbia, Canada	Rob Buchanan, Senior Geoscientist TRAN:EX, Rob.Buchanan@gov.bc.ca 250-387-7702	Privatized	The province of British Columbia and the Ministry of Transportation have privatized all maintenance operations for highways and the secondary road network. Within these contracts dead animals on the road come under the definition of debris. Debris: "litter, rubbish, vegetation, fallen rocks, dead animals, spilled materials, brush, branches or other	In the past, disposal methods were the same as you have described, with most of the carcasses going to roadside gravel pits. Approximately 8 years ago, this method of disposal was discontinued due to health and water quality issues.

State	Contact	Pick Up	Disposal	Comments
			tree components or other items, which are not part of the Highway by intention."	
California	Herby Lissade, Caltrans Maintenance Division	Hwy Maintenance from State R/W when local disposal not available	Reference: Maintenance Manual, Each Superintendent should establish a procedure for the removal of dead animals from the State right of way	Local animal control agencies handle injured, dying, or dead animals where available. When not available, the Superintendent should select the most reasonable form of disposal, including authorized dumps or burial, considering local rules and regulations. Disposal methods vary throughout the state depending on District and geographical region
Florida	Richard C. Long, Director Research and Development Center (850)414-4617 richardc.long@dot.state.fl.us	Highway maintenance force	Florida DOT Maintenance Units disposes of animal carcasses in compliance with local ordinances in their geographical area.	
Georgia	David Crim, State Maintenance Engineer, (404)635-8734 David.Crim@dot.state.ga.us	Hwy maintenance force	No specific written policy; Utilize the same procedures as mentioned. We are also experiencing difficulty in the urban areas but thus far have only used land fills for disposals.	

State	Contact	Pick Up	Disposal	Comments
Illinois	David B Johnson, Maintenance Operations Engineer, Illinois DOT 126 East Ash Street, 217/782-2984 Springfield, Illinois 62704-4766 JOHNSONDB@dot.il.gov	Hwy maintenance	The Illinois Department of Transportation does not have any formal policy on disposing of roadkill. Past practices include burying on ROW, disposal at land fills and incineration.	
Iowa	William Zitterich, Assistant Maintenance Director, Iowa DOT William.Zitterich@dot.iowa.gov 515-239-1396	[DOT	They are buried in the Right of Way or taken to an unseen part of the Right of Way or taken to a landfill. They may also be brought to a rendering plant or an installation furnishing incineration in urban areas.	We have considered purchasing incinerators at maintenance garages to dispose of carcasses but this is not cost effective.
Kentucky	Mike A. Smith Roadside Environment Consultant (502) 564-4556 MikeA.Smith@ky.gov	State Highway	Like many states, the KY. Dept of Highways is struggling with the issue of how to dispose of the tens of thousands of road kill animals we must pick up each year. 95% of our work involves deer. We currently use a variety of methods to dispose of road kill animals. When possible, we try to dispose of them on the ROW either by burial or if they are out of the view of traffic in a rural area-- we will lime them and allow natural decomposition to occur. In one district, they are taken to a municipal	We have not generated a sizeable amount of compost so far, but we plan to use the compost as a soil amendment to improve a roadside site. We have investigated purchasing our own incinerator units for each county to use, but the cost to buy one of them for each of our 120 counties is not palatable at this time. Our environmental policy manual is being updated at this time, so we hope to include composting as an alternative disposal method.

			incinerator. We only have one district that is composting at this time and this is used to handle the overflow from weekends since landfills and municipal incinerators are closed then. Our people are using wood chips as a composting medium and the composting bin was constructed using obsolete barrier wall segments. They report no problems with odors and the process	
Louisiana	Karl Finch KarlFinch@dotd.louisiana.gov	State	Bury the carcasses on state owned right of way or dispose of them at county landfills. First we try to ascertain the name of the owner because of liability and legal issues plus knowing who to bill for the removal.	
Maryland	Charles Bull Office of Maintenance Hanover, MD cbull@sha.state.md.us	Hwy maintenance staff	Bury on state r/w, landfill where available and compost in 1 district	

State	Contact	Pick Up	Disposal	Comments
Minnesota	Bob Wryk, Northwest Region Superintendent, Metro Division 651-775-0369 robert.wryk@dot.state.mn.us	Hwy maintenance staff	If the deer is in a urban area, as most of them are, we have three options: #1 load them up and take them to a couple designated Truck Stations where we compost them with wood chips and then use the compost out on the roadside in some of our landscape areas. #2 Load them up and take them to a designated landfill. We don't do this very often it is quite expensive and the haul time also adds to the cost. #3 is something that we are just experimenting with; it is called "The Dutch Composter". It looks like a silo which can hold up to 2000 pounds of material What the machine does is it heats, grinds, and mixes any road kill with wood chips and straw and in 48 to 96 hours you end up with a very fine dirt like looking compost.	
Mississippi	John Vance, P. E. State Maintenance Engineer jvance@mdot.state.ms.us	State hwy force	Bury the carcasses on state owned right of way or dispose of them at county landfills	
Missouri	Tim Jackson, Technical Support Engineer, Missouri DOT P.O. Box 270 Jefferson City, MO 65102	State hwy force	Missouri Dept. of Transportation has a policy on the disposal of animal carcasses in our Maintenance Policy Manual.	<ul style="list-style-type: none"> ◆ Missouri policy ◆ Bury the carcass on highway right-of-way, provided it is not prohibited by local ordinances ◆ Dispose of the animal carcass at a state-

	573-526-1884, 573-526-4868 Fax Timothy.Jackson@modot.mo.gov			<p>approved sanitary landfill, with the landfill operator's approval.</p> <ul style="list-style-type: none"> ◆ Dispose of the carcass in an animal compost bin, which can be built at a maintenance facility. ◆ Dispose of the carcass at a site and in a manner pre-approved by the MDC. ◆ Where available, the carcass may be taken to a city or county animal control facility equipped to dispose of animal carcasses
Nebraska	Dalyce Ronnau, Operations & Maintenance, Nebr. Dept of Roads P.O. Box 94759 Lincoln NE 68509-4759 Tel. (402)479-4544 dronnau@dor.state.ne.us	State hwy force	The Nebraska Department of Roads, for the most part, simply drags the dead animal into the tall grass along the roadside and lets nature take its course. Being a rural state, this generally does not pose any problems. In some cases, larger animals may be disposed of in landfills if accepted.	Nebraska doesn't have any formal program to deal with this.
New Jersey	Nicholas P. Vitillo, Ph. D. Manager, Bureau of Research NJ Department of Transportation PO Box 600 Trenton, NJ 08625-0600 Nick.Vitillo@dot.state.nj.us (609) 530-5637 (609) 530-3722 FAX	uses contractors	Due to the "Mad Cow Scare" the contractors are required to landfill all the carcasses.	<p>A copy of the contract can be viewed at the Treasury web site: http://www.state.nj.us/treasury/purchase/contracts.htm Key word "deer".</p> <p>Contact Lawrence.Sroka@dot.state.nj.us</p>

State	Contact	Pick Up	Disposal	Comments
<u>New Mexico</u>	Virgil N Valdez or Walter Adams (Quality Bureau - 827-5451) Tom Raught, State Maintenance Engineer Tom.Raught@nmshtd.state.nm.us	State hwy force or Game & Wildlife	No Written Policy but has an established procedure for pets, livestock and wildlife hits. Owner responsible for pets and livestock if can be determined or hall to a disposal site.	Wildlife hits. We will contact our Game and Fish Department for documentation. Game and Fish will occasionally contact a local person on fresh kills, (Deer, Antelope and Elk) to collect the animal for processing (Butchering). Most of the time we haul it to a disposal site.
<u>North Carolina</u>	Scott Capps, Maintenance Operations Engineer, scapps@dot.state.nc.us	State Hwy force or county	We either bury on-sight or dispose of at an accepting County landfill.	Facing problem of landfills not accepting animal carcasses, so we are very interested in the results of your survey to see if other alternatives exist. Wake County has a contract for \$24.75/carcass. The contractor is then responsible for disposal and any associated tipping fees at disposal locations.
Pennsylvania	Jonathan Fleming, Roadside Specialist Penn DOT, (717) 772-1771 jonfleming@state.pa.us	Contract	PennDOT can account for approximately 45,000 deer carcasses removed from state highways per year. Utilizes a combination of removal strategies, each associated with a different method of disposal. PennDOT has considered and researched the option of composting RKD. At the present, the Pennsylvania Department of Environmental Protection is working on the application and permit requirements for composting sites. The future of RKD composting in Pennsylvania still remains an option.	PennDOT contracts with private vendors for the removal of RKD on selected traffic routes. They're responsible for the disposal of the deer in certified landfills. The vendor must provide a receipt of delivery from the landfill to in order to bill for their services. At the present time, the average price of removal and disposal is \$36 per carcass. We also work through agreement with the PA Game Commission (PGC.) In rural areas or residential properties are referred to the PGC for removal and disposal. PGC utilizes deer pits as their disposal method. We remove from the travel lanes and allow decomposing naturally. RKD located in limited right of way areas and watershed areas are relocated to

				forested areas or removed to a landfill.
South Dakota	John C. Forman, P.E. State Construction & Maintenance Engineer South Dakota DOT 700 East Broadway Ave. Pierre, SD 57501, (605) 773-3704; Fax (605) 773-6600 john.forman@state.sd.us	Contract s for a large portion of deer kill pickup	Shares the cost 50/50 with the Dept of Game, Fish & Parks for animals picked up on state highways	The carcasses are generally taken to a landfill, but we do not direct where these carcasses need to be taken. Our average cost is between \$25-\$30/carcass.
Texas	Zane Webb, TxDOT, ZWEBB@dot.state.tx.us	TxDOT	TxDOT has specific legislation allowing us to bury dead animals. In urban areas, we dispose in landfills.	See Section 361.117(b), Texas Health and Safety Code: TITLE 5. SANITATION AND ENVIRONMENTAL QUALITY http://www.capitol.state.tx.us/statutes/docs/HS/content/htm/hs.005.00.000361.00.htm
Vermont	Mike Morissette, Mike.Morissette@state.vt.us	VTrans picks up small animals.	Vtrans is only responsible for disposing of road kill animals smaller than deer. The Fish and Wildlife Department takes care of larger animals. Our general practice in rural areas, away from homes is to simply drag the animal off the road into the woods.	Has a policy developed by the veterinarian, but doubts that it is used.

State	Contact	Pick Up	Disposal	Comments
Washington	Rico Baroga, BarogaR@wsdot.wa.gov	State	Our past practices include burying on ROW, disposal at land fills and incineration	The Washington State DOT does not have a formal policy or procedure to direct the disposal of roadkill from state highways. A variety of practices are used dependent on the area and related circumstances.
West Virginia	Robert A. Amtower, P.E., Assistant District Engineer - Maintenance P.O. Box 99 Burlington, West Virginia 26710 Phone: (304) 289-3521 ramtower@dot.state.wv.us	Hwy forces	Our district which is the seven counties of the Eastern Panhandle of West Virginia has a composter in each county to handle "road kill". We have been doing this since 1997. We dispose of about 3,500 dead deer in the panhandle, seven compost buildings.	
Wisconsin	John Kinar, 608.266.1202, john.kinar@dot.state.wi.us	Combined	Small animal carcasses are either taken to a sanitary landfill or they are disposed of beyond the ditch line, preferably in the woods (the latter method is limited to rural areas). Department of Natural Resources contracts with private contractors to remove deer carcasses from the highway and take them to sanitary landfills.	

7.2 APPENDIX B: A CHART LISTING COMMON COMPOSTING MATERIALS

Type of Material	Use it?	Carbon/ Nitrogen	Details
Algae, seaweed and lake moss	Yes	N	Good nutrient source.
Ashes from coal or charcoal	No	n/a	May contain materials bad for plants.
Ashes from untreated, unpainted wood	Careful	Neutral	Fine amounts at most. Can make the pile too alkaline and suppress composting.
Beverages, kitchen rinse water	Yes	Neutral	Good to moisten the middle of the pile. Don't over-moisten the pile.
Bird droppings	Careful	N	May contain weed seeds or disease organisms.
Cardboard	Yes	C	Shred into small pieces if you use it. Wetting it makes it easier to tear. If you have a lot, consider recycling instead.
Cat droppings or cat litter	No	n/a	May contain disease organisms. Avoid.
Coffee ground and filters	Yes	N	Worms love coffee grounds and coffee filters.
Compost activator	Not required, but ok.	Neutral	You don't really need it, but it doesn't hurt.
Cornstalks, corn cobs	Yes	C	Best if shredded and mixed well with nitrogen rich materials.
Diseased plants	Careful	N	If your pile doesn't get hot enough, it might not kill the organisms, so be careful. Let it cure several months, and doesn't use resulting compost near the type of plant that was diseased.
Dog droppings	No	n/a	Avoid.
Dryer lint	Yes	C	Compost away! Moistening helps.
Eggshells	Yes	O	Break down slowly. Crushing shells helps.
Fish scraps	No	n/a	Can attract rodents and cause a stinky pile.
Hair	Yes	N	Scatter so it isn't in clumps.
Lime	No	n/a	Can kill composting action. Avoid.
Manure (horse, cow, pig, sheep, goat, chicken, rabbit)	Yes	N	Great source of nitrogen. Mix with carbon rich materials so it breaks down better.

Meat, fat, grease, oils, bones	No	n/a	Avoid.
Milk, cheese, yogurt	Careful	Neutral	Put it deep in the pile to avoid attracting animals.
Newspaper	Yes	C	Shred it so it breaks down easier. It is easy to add too much newspaper, so recycle instead if you have a lot. Don't add slick colored pages.
Oak leaves	Yes	C	Shredding leaves helps them break down faster. They decompose slowly. Acidic.
Sawdust and wood shavings (untreated wood)	Yes	C	You'll need a lot of nitrogen materials to make up for the high carbon content. Don't use too much, and don't use treated woods.
Pine needles and cones	Yes	C	Don't overload the pile. Also acidic and decomposes slowly.
Weeds	Careful	N	Dry them out on the pavement, and then add later.
Sod	Careful	N	Make sure the pile is hot enough, so grass doesn't continue growing.

For more information or a complete publication list, contact us at:

KENTUCKY TRANSPORTATION CENTER

176 Raymond Building
University of Kentucky
Lexington, Kentucky 40506-0281

(859) 257-4513
(859) 257-1815 (FAX)
1-800-432-0719
www.ktc.uky.edu
ktc@engr.uky.edu

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